

Inpatient Hospitalizations of U.S. Military Personnel Medically Evacuated From Iraq and Afghanistan With Combat-Related Traumatic Brain Injury

Kevin J. Heltemes, MPH; Amber L. Dougherty, MPH;
LCDR Andrew J. MacGregor, MSC USN; Michael R. Galarneau, MS

ABSTRACT Traumatic brain injury (TBI) has been called the signature wound of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). The aim of the present study was to describe and assess the incidence of inpatient hospitalizations of U.S. military personnel who were medically evacuated from OIF and OEF with combat-related TBI. Inpatient medical records from 2003 to 2008 were used to determine incident episodes of TBI requiring hospitalization in Landstuhl or CONUS Regional Medical Centers. Denominator data for calculating incidence rates were available from the Defense Manpower Data Center. During the study period, 1,213 U.S. military personnel from OIF and OEF were hospitalized with combat-related TBI. Of these, the largest proportion (40.9%) occurred in 2007. The rate of inpatient hospitalization with TBI was 10.4 per 10,000 troop strength (95% confidence interval: 9.9, 10.9). Future research should examine the incidence of TBI in-theater and include an analysis by injury severity.

INTRODUCTION

Traumatic brain injury (TBI) has been called the signature wound of the current conflicts in Iraq and Afghanistan, where more than 50% of some combat-injured populations incurred wounds to the head, neck, and face.¹ This percentage is significantly higher than that observed in World War II and the Korean and Vietnam wars.^{2,3} The emergence of novel blast mechanisms, such as improvised explosive devices, has purportedly led to this increase.¹ Furthermore, advancements in personal protective equipment (e.g., Kevlar helmets) and battlefield medical care have rendered previously fatal wounds survivable.^{4,5} This increase in the prevalence and survivability of TBIs has greatly impacted military inpatient and rehabilitative medical care.^{2,6-20}

The financial burden of TBI on the military health care system, which includes costs related to lost duty days, initial medical treatment, rehabilitation, and continual care, is significant.²¹⁻²⁴ TBI-related costs among military personnel, dependents, and retirees place substantial fiscal demand on the military health care system.²² The additional strain on logistical and manpower requirements related to medical evacuations and hospitalizations is also of primary importance during a time of war.²³

A recent report of service members injured in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) who were hospitalized at Walter Reed Medical Center indicated that the majority (59%) were admitted with TBI.⁶ The

lack of an appropriate denominator in this analysis, however, precluded comparisons across time and among subgroups, and, as such, the incidence of combat-related TBI requiring inpatient hospitalization is not known. The objective of this study was to describe and assess the incidence of inpatient hospitalizations of U.S. military personnel who were medically evacuated from Iraq and Afghanistan with combat-related TBI across all branches of service.

METHODS

Study Population

The study population consisted of active-duty U.S. Army, Navy, Marine Corps, and Air Force personnel injured in combat during OIF and OEF, and who were hospitalized in Landstuhl or CONUS Regional Medical Centers with TBI from March 2003 to September 2008. Inpatient diagnoses were obtained from service member's medical records (i.e., Standard Inpatient Data Records) managed by the Office of the Secretary of Defense for Health Affairs, TRICARE Management Activity. Diagnoses were coded by credentialed providers at military treatment facilities using *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes.²⁵ Denominator data for calculating incidence rates were obtained from the Defense Manpower Data Center.

Measures

The primary case selection criteria for a patient with TBI was an inpatient hospitalization diagnosis of any one of the following ICD-9-CM codes: 800.0–801.9 or 803.0–804.9 (fracture of skull), 850.0–854.1 (intracranial injury, excluding those with skull fracture), or 959.01 (head injury, unspecified). In addition to these ICD-9-CM codes, supplemental

Naval Health Research Center, 140 Sylvester Road, San Diego, CA 92106.

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. This research was conducted in compliance with all applicable federal regulations governing the protection of human subjects.

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE Impatient Hospitalizations Of U.S. Military Personnel Medically Evacuated From Iraq And Afghanistan With Combat-Related Traumatic Brain Injury			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Health Research Center, 140 Sylvester Rd, San Diego, CA, 92106			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Military Medicine, Vol 176, Feb 2011, Preprinted					
14. ABSTRACT Traumatic brain injury (TBI) has been called the signature wound of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). The aim of the present study was to describe and assess the incidence of inpatient hospitalizations of U.S. military personnel who were medically evacuated from OIF and OEF with combat-related TBI. Impatient medical records from 2003 to 2008 were used to determine incident episodes of TBI requiring hospitalization in Landstuhl or CONUS Regional Medical Centers. Denominator data for calculating incidence rates were available from the Defense Manpower Data Center. During the study period, 1,213 U.S. military personnel from OIF and OEF were hospitalized with combat-related TBI. Of these, the largest proportion (40.9%) occurred in 2007. The rate of inpatient hospitalization with TBI was 10.4 per 10,000 troop strength (95% confidence interval: 9.9, 10.9). Future research should examine the incidence of TBI in-theater and include an analysis by injury severity.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

ICD-9-CM “external cause of injury” (E codes) and Standard NATO Agreement “cause of injury” (STANAG 2050) codes were used to elaborate on the circumstances of the injuries. The description of E codes are “injury resulting from operations of war” (E990-E999), and the description of STANAG 2050 codes are injuries because of “instrumentalities of war, when employed by the enemy in wartime” (300-479), “accidents in connection with own instrumentalities of war, when employed in wartime” (480-499), and “guns, explosives, and related agents” (500-599).

Demographic variables provided a description of the study population, including age at disposition, rank, bed days, length of service, and number of deployments. Rank was categorized as enlisted (E1-E3, E4-E5, and E6-E9) or officer (including Warrant Officers). “Bed days” are calculated in the Standard Inpatient Data Records as the number of days a patient occupied a bed and counted where the patient was at the census-taking hour in the treatment facility. A bed day was counted when a patient was admitted and discharged on the same day.

Data Analysis

Analyses were primarily descriptive, including frequency distributions and incidence rates. The Kruskal-Wallis test was used to compare median age and bed days across the branches of service. Chi-square (χ^2) tests were used to assess categorical variables. Tests were 2-tailed and $p < 0.05$ was used to determine statistical significance. All statistical analyses were performed using SPSS software, version 16.0 (SPSS, Inc; Chicago, Illinois). This study was approved by the Institutional Review Board at Naval Health Research Center, San Diego, California.

RESULTS

During the study period, 1,213 patients with combat-related TBI were hospitalized in Landstuhl or CONUS Regional Medical Centers. Of these, 23 patients were admitted with multiple brain injuries. The median age was 23 years, with a range of 18 to 56 years. All but 16 patients were men. Nine hundred and fifty-four patients were Army personnel, 218 were Marines, 29 were Navy, and 12 were Air Force. Thirty-seven patients died of their wounds during hospitalization. The majority of patients were injured by “guns, explosive, and related agents” (81.3%), followed by other “instrumentalities of war, when used by the enemy in wartime” (16.9%) and “accidents in connection with own instrumentalities of war, when used in wartime” (0.3%). The remaining 1.5% of patients had an E code that indicated “injury resulting from operations of war.” Among all TBI diagnoses ($n = 1,286$), 59.7% were categorized as “intracranial injury, excluding skull fracture,” 39.3% were “fracture of skull,” and 0.9% were “head injury, unspecified.” The distribution of all TBI diagnoses according ICD-9-CM categories is shown in Table I.

Demographic and injury-specific differences between the branches of service are shown in Table II. Marines

TABLE I. Frequency and Percent Distribution of Traumatic Brain Injury Diagnoses for U.S. Military Personnel Hospitalized With Combat-Related TBI, Operations Iraqi and Enduring Freedom, 2003–2008

ICM-9-CM Category	Description	N (%)
800.00–0.99	Fracture of Vault of Skull	102 (7.9)
801.00–0.99	Fracture of Base of Skull	332 (25.8)
803.00–0.99	Other and Unqualified Skull Fractures	60 (4.7)
804.00–0.99	Multiple Fractures Involving Skull or Face With Other Bones	12 (0.9)
850.0–0.9	Concussion	449 (34.9)
851.00–0.99	Cerebral Laceration and Contusion	83 (6.5)
852.00–0.59	Subarachnoid, Subdural, and Extradural Hemorrhage Following Injury	45 (3.5)
853.00–0.19	Other and Unspecified Intracranial Hemorrhage Following Injury	37 (2.9)
854.00–0.19	Intracranial Injury of Other and Unspecified Nature	154 (12)
959.01	Head Injury, Unspecified	12 (0.9)
Total Traumatic Brain Injury Diagnoses		1,286 (100.0)

hospitalized with combat-related TBI were statistically younger than those in the other branches of service ($\chi^2 = 79.39$, $df = 3$, $p < 0.01$). Likewise, Marines also had the highest proportion of junior enlisted (E1–E3) service members. The largest proportion of Army, Air Force, and Navy patients hospitalized with combat-related TBI were in the E4 to E5 range. The average length of hospitalization (bed days) for combat-related TBI was 16 days for all services. The range of bed days, however, varied considerably; from 1 to 289 days among Army personnel and 1 to 66 days among Air Force personnel. The Air Force patients hospitalized with combat-related TBI had the longest service record (83.3% served 3 or more years).

The rate of combat-related TBI hospitalization among all services was 10.4 per 10,000 troop strength (95% confidence interval: 9.9, 10.9). As shown in Table III, incidence rates differed significantly by service. Although the majority of combat-related TBI hospitalization events occurred in Army personnel (78.6%), Marines had a higher incidence rate than Army members (13.5 vs. 10.9 per 10,000 troop strength). The Navy and Air Force had significantly lower incidence of combat-related TBI hospitalizations than the Army ($p < 0.001$).

Overall, the proportion of TBI hospitalizations increased during the study period and peaked in 2007, with 40.9% (496 of 1,213) of the study population hospitalized for combat-related TBI in this year. Trends in incidence rates of TBI hospitalizations differed by branch of service. TBI hospitalizations among Marines peaked in 2004 with an incidence rate of 22.0 per 10,000 troop strength and declined to a rate of 5.3 per 10,000 troop strength by 2008. Among Army personnel, however, rates of TBI hospitalizations increased from 6.4 per 10,000 troop strength in 2004 to 28.4 per 10,000 troop strength in 2007 (Fig. 1).

TABLE II. Characteristics of U.S. Military Personnel Hospitalized With Combat-Related TBI by Branch of Service, Operations Iraqi and Enduring Freedom, 2003–2008

Characteristic	Total (n = 1,213)	Army (n = 954)	Air Force (n = 12)	Marine Corps (n = 218)	Navy (n = 29)	p Value
Sex, n (%) ^a						
Male	1,197 (98.7)	939 (98.4)	12 (100.0)	218 (100.0)	28 (96.6)	
Female	16 (1.3)	15 (1.6)	0 (0.0)	0 (0.0)	1 (3.4)	
Age (years), median (range)	23 (18–56)	24 (18–56)	26.5 (19–40)	21 (18–48)	26 (19–48)	<0.01
Rank, n (%)						<0.001
E1–E3	395 (32.6)	261 (27.4)	3 (25.0)	121 (55.5)	10 (34.5)	
E4–E5	570 (47.0)	478 (50.1)	5 (41.7)	76 (34.9)	11 (37.9)	
E6–E9	175 (14.4)	155 (16.2)	1 (8.3)	13 (6.0)	6 (20.7)	
Officer	73 (6.0)	60 (6.3)	3 (25.0)	8 (3.7)	2 (6.9)	
Bed Days, median (range)	16 (1–289)	16 (1–289)	22 (1–66)	15 (1–196)	28 (1–95)	0.14
Length of Service (years), n (%)						0.06
≤2	454 (37.4)	369 (38.7)	2 (16.7)	73 (33.5)	10 (34.5)	
3–9	634 (52.3)	480 (50.3)	9 (75.0)	131 (60.1)	14 (48.3)	
≥10	125 (10.3)	105 (11.0)	1 (8.3)	14 (6.4)	5 (17.2)	

^aχ² test was not calculated because of insufficient cell sizes.

TABLE III. Incidence Rates for Combat-Related TBI Hospitalization Among Deployed U.S. Military Personnel by Branch of Service, Operations Iraqi and Enduring Freedom, 2003–2008

Branch of Service	Rate per 10,000 Troop Strength	95% Confidence Interval	p Value
Marine Corps	13.5	11.7, 15.6	<0.01
Navy	5.7	3.9, 8.2	<0.001
Air Force	1.6	0.9, 2.8	<0.001
Army	10.9	Reference	

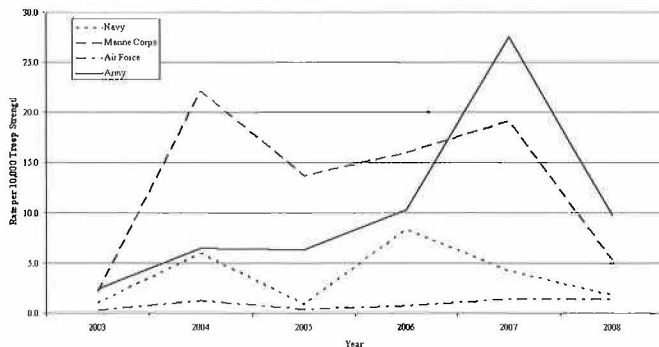


FIGURE 1. Trends in incidence rates of combat-related TBI hospitalization among deployed U.S. military personnel by branch of service, Operations Iraqi and Enduring Freedom, 2003–2008.

DISCUSSION

This study assessed the incidence of combat-related TBI hospitalizations during OIF and OEF across all services. Compared with the Army, Marines had the highest risk of combat-related TBI during the current conflicts in Iraq and Afghanistan. Previous research indicates that differences in service-specific missions yield varying casualty distributions.²⁶ For instance, a much higher proportion of head and neck injuries

were found among OIF and OEF veterans compared to past conflicts, including World War II, Korean War, and Vietnam War.²⁷ Further, Marines are an expeditionary force primarily deployed during periods of high combat intensity, and as such, it may be expected that their rates of injury due to combat are higher than the rates of injury of other services. Notably, Marines had the highest incidence rate near the beginning of the conflict in Iraq (in 2004), during the highest combat intensity period (i.e., Second Battle of Fallujah).

To our knowledge, this is the first study to assess combat-related incidence of TBI hospitalizations in Landstuhl and CONUS Regional Medical Centers and to compare risk of hospitalization by branch of service. Although this study provides important information regarding the incidence of TBI hospitalizations by service, there are limitations. The data were not collected for the purpose of this study. Incident information did not include measures of TBI severity, and denominator data collected from Defense Manpower Data Center to calculate incidence rates did not include information on other variables such as age or rank. As such, we were unable to assess or control for the impact of these variables on the incidence rates. The use of an appropriate denominator (i.e., deployed population-at-risk), however, was imperative for calculating incidence rates across services, and this is the first study to identify the overall rate of TBI requiring hospitalization among those deployed in OIF and OEF. Further, it is important to note that the present analysis only examined inpatient hospitalizations from Landstuhl or CONUS Regional Medical Centers. Those patients who were treated for their injuries in-theater and returned to duty or died in-theater were not included in the study, which may have underestimated the true incidence of combat-related TBI.

Reporting the incidence of combat-related TBI is important to support medical planners in determining the demand for resources required at medical treatment facilities and hospitals in-theater and in CONUS. Future studies might

examine additional resources required for combat-related TBI by injury severity and determine the impact of all types of TBI in-theater to assist the military health care community. In addition, research should elucidate the service-specific differences in TBI incidence after controlling for the effects of associated risk factors, such as military occupational specialty.

ACKNOWLEDGMENTS

We thank Science Applications International Corporation for its contributions to this work. This work was supported by the U.S. Navy Bureau of Medicine and Surgery, Washington, DC, under Work Unit No. 60808.

REFERENCES

1. Wade AL, Dye JL, Mohrle CR, Galarneau MR: Head, face, and neck injuries during Operation Iraqi Freedom II: results from the US Navy-Marine Corps Combat Trauma Registry. *J Trauma* 2007; 63: 836-40.
2. Owens BD, Kragh JF Jr, Wenke JC, Macaitis J, Wade CE, Holcomb JB: Combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom. *J Trauma* 2008; 64: 295-9.
3. Reister FA: Battle Casualties and Medical Statistics: US Army Experience in the Korean War, Chapter 3. Washington, DC, Department of the Army, Office of the Surgeon General, 1973.
4. Xydakis MS, Fravell MD, Nasser KE, Casler JD: Analysis of battlefield head and neck injuries in Iraq and Afghanistan. *Otolaryng Head Neck* 2005; 133: 497-504.
5. Gawande A: Casualties of war: military care for the wounded from Iraq and Afghanistan. *New Engl J Med* 2004; 351: 2471-5.
6. Okie S: Traumatic brain injury in the war zone. *New Engl J Med* 2005; 352: 2043-7.
7. Bryant R: Posttraumatic stress disorder and traumatic brain injury: can they co-exist? *Clin Psychol Rev* 2001; 21: 931-48.
8. eMedicine. Classification and complications of traumatic brain injury. Available at <http://emedicine.medscape.com/article/326643-overview>; accessed May 21, 2008.
9. Shordone RJ, Liter JC: Mild traumatic brain injury does not produce post-traumatic stress disorder. *Brain Inj* 1995; 9: 405-12.
10. Mayo Clinic. Depression. Available at <http://www.mayoclinic.com/health/depression/DS00175>; accessed June 5, 2008.
11. Jorge RE, Robinson RG, Arndt SV, Starkstein SE, Forrester AW, Geisler F: Depression following traumatic brain injury: a 1 year longitudinal study. *J Affect Disord* 1993; 27: 233-43.
12. McCleary C, Satz P, Forney D, et al: Depression after traumatic brain injury as a function of Glasgow Outcome Score. *J Clin Exp Neuropsychol* 1998; 20: 270-9.
13. Seel RT, Kreutzer JS, Rosenthal M, Hammond F, Corrigan JD, Black K: Depression after traumatic brain injury: a National Institute on Disability and Rehabilitation Research Model Systems multicenter investigation. *Arch Phys Med Rehabil* 2003; 84: 177-84.
14. Annegers JF, Hauser WA, Coan SP, Rocca WA: A population-based study of seizures after traumatic brain injuries. *New Engl J Med* 1998; 338: 20-4.
15. Mayo Clinic. Epilepsy. Available at www.mayoclinic.com/health/epilepsy/DS00342; accessed June 5, 2008.
16. Mayo Clinic. Dysphagia. Available at www.mayoclinic.com/health/dysphagia/DS00523; accessed June 5, 2008.
17. Morgan A, Ward F, Murdoch B, Kennedy B, Murison R: Incidence, characteristics, and predictive factors for dysphagia after pediatric traumatic brain injury. *J Head Trauma Rehab* 2003; 18: 239-51.
18. Mayo Clinic. Hydrocephalus. Available at www.mayoclinic.com/health/hydrocephalus/DS00393; accessed June 5, 2008.
19. Mazzini L, Campini R, Angelino E, Rognone F, Pastore I, Oliveri G: Posttraumatic hydrocephalus: a clinical, neuroradiologic, and neuropsychologic assessment of long-term outcome. *Arch Phys Med Rehabil* 2003; 84: 1637-41.
20. Tawil I, Stein DM, Mirvis SE, Scalea TM: Posttraumatic cerebral infarction: incidence, outcome, and risk factors. *J Trauma* 2008; 64: 849-53.
21. Thompson K, Antony A, Holtzman A: The costs of traumatic brain injury. *N C Med J* 2001; 62: 381-4.
22. Ommaya AK, Ommaya AK, Dannenberg AL, Salazar AM: Causation, incidence, and costs of traumatic brain injury in the U.S. military medical system. *J Trauma* 1996; 4: 211-7.
23. Max W, MacKenzie EJ, Rice DP: Head injuries: costs and consequences. *J Head Trauma Rehab* 1991; 6: 76-91.
24. Lauder TD, Baker SP, Smith GS, Lincoln AE: Sports and physical training injury hospitalizations in the Army. *Am J Prev Med* 2000; 18 (3 Suppl): 118-28.
25. Larson GE, Highfill-McRoy RM, Booth-Kewley S: Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect. *Am J Epidemiol* 2008; 167: 1269-76.
26. Zouris JM, Wade AL, Magno CP: Injury and illness casualty distributions among U.S. Army and Marine Corps personnel during Operation Iraqi Freedom. *Mil Med* 2008; 173: 247-52.
27. Zouris JM, Walker GJ, Dye J, Galarneau M: Wounding patterns for U.S. marines and sailors during operation Iraqi freedom, major combat phase. *Mil Med* 2006; 171: 246-52.

Reprinted with permission from the Association of Military Surgeons of the U.S.